MEMORANDUM OF UNDERSTANDING

FOR THE 2008-2009 MESON TEST BEAM PROGRAM

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AIRFLY Collaboration

Argonne National Laboratory, Czech Academy of Science, Fermi National Accelerator Laboratory, University of Chicago, University of L'Aquila, University of Rome Tor Vergata

December 1, 2008

INTRODUCTION

This is a memorandum of understanding between the Fermi National Accelerator Laboratory (Fermilab) and Argonne National Laboratory, Czech Academy of Science, Fermi National Accelerator Laboratory, Forschungszentrum Karlsruhe, University of Chicago, University of L'Aquila, University of Rome Tor Vergata experimenters who have committed to participate in beam tests to be carried out during the 2008-2009 Meson Test Beam Facility program. The memorandum is intended solely for the purpose of providing a budget estimate and a work allocation for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to negotiate the appropriate amendments to this memorandum if adjustments are required.

The experimenters require beam time at Fermilab during the 2008-2009 Meson Test Beam Run to perform a precise measurement of air fluorescence yield from nitrogen excitation by charged particles. This measurement will allow for a substantial reduction of the systematic uncertainty on the energy determination of ultra-high energy cosmic rays ($> 10^{18}$ eV) by the Pierre Auger Observatory.

The AIRFLY Collaboration has already performed measurements of the fluorescence yield at several accelerators in Frascati, Italy and Argonne, US. The groups of the University of Chicago and Fermilab have been awarded a Strategic Collaborative Initiative grant to perform the air fluorescence measurement at the Fermilab Meson Test Beam.

A sketch of the apparatus is shown in Fig. 1. The beam particles enter a dark box where an integrating sphere is placed. Fluorescence photons emitted along the beam axis within the integrating sphere are diffused by the interior coating of the sphere, and eventually reach the photon detector through a 90° exit port. Photomultipliers as well as Hybrid Photon Detectors (HPD) will be used. A 337 nm interference filter in front of the photon detector selects the main fluorescence emission band. The Cherenkov emission will also be measured in separate runs. The Cherenkov light emitted by the beam particles along their path in the integrating sphere will be diffused by closing the beam exit port with a port plug of the same material as the interior coating of the sphere. From the ratio of the measured fluorescence to the Cherenkov signal, the absolute fluorescence yield is determined. Since the same photon detector is used in both measurements, the systematic uncertainty due to the quantum efficiency is significantly reduced. Beam particles are triggered by 1 cm^2 scintillators placed at the entrance and exit ports of the integrating sphere. Additional veto scintillators counters are used to eliminate halo particles. An independent cross-check of the measurement will be provided by an in situ calibration of the photon detectors. Light from a 337 nm nitrogen laser beam is Rayleigh scattered into the integrating sphere. The laser power is measured by a NIST power meter with 5% accuracy. Since the number of photons scattered away from the laser beam can be precisely calculated, a calibration of the photon detectors is achieved.

The experimenters ask for a first test beam to be performed in December 2008. The goal of this first test beam is the understanding of the beam characteristics, in particular intensities and backgrounds. This will be achieved by the experimenters through the analysis of the data which will be collected during the test beam. Preliminary measurements of the absolute fluorescence yield with the fluorescence to Cherenkov ratio method will be performed.

A second test beam is foreseen in March or June 2009, the exact date depending on the results of the first test beam and beam availability. The 2009 test beam will involve a complete apparatus, including a gas system to change pressure in the fluorescence chamber. The laser calibration will also be performed. This second test beam will provide the main data set for the precision measurement of the fluorescence yield. The measurement will be performed in a variety of configurations to study systematic uncertainties, including different particle beams, different interference filters and photon detectors.

I. PERSONNEL AND INSTITUTIONS:

Spokesman and physicist in charge of beam tests: Paolo Privitera, University of Chicago

Fermilab liaison: Carlos Hojvat, Erik Ramberg

The group members at present and others interested in the test beam are:

1.1 Fermilab: Carlos Hojvat, H. Glass
1.2 University of Chicago: Paolo Privitera, Pedro Facal, Martina Bohacova, Lorenzo Cazon, Chris Williams, Jesse Marshall
1.3 Argonne National Laboratory: H. Spinka
1.4 University of Rome Tor Vergata: V. Verzi
1.5 University of L'Aquila: S. Petrera, F. Salamida
1.6 Czech Academy of Science: J. Ridky
1.7 Forschungszentrum Karlsruhe: H. Klages, A Obermeier

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 LOCATION

2.1.1 The tests are to be performed in the MTEST beam line in the MT6-1B and/or MT6-2B areas.

2.1.2 The experimenters will need some Fermilab support to align the apparatus relative to the beam line. The following items will be needed in the beam area:

- a table where to place the dark box
- a 2-counter beam telescope of 1 cm x 1 cm active area , to be placed at the entrance and exit of the fluorescence chamber. (see Fig. 1). Both timing and charge signals from these counters, to establish an independent trigger and to be sure to trigger on a single particle
- one or more large area counter to measure the beam halo.
- Test-beam beam condition, trigger, and hodoscope information.
- beam-spill and gating signals, monitoring of beam intensity
- 1 19-inch racks with wheels, cooling, and a 110V power strip to house one NIM and one VME crate
- An ethernet cable from the beam area to the counting room is needed to control the VME DAQ

2.1.3 Additional work space will be needed in the alcove control room, equivalent to two 6' x 3' tables. This space will be used for the data acquisition PC and as general work space.

2.2 BEAM

2.2.1 BEAM TYPES

For the December 2008 test beam, the experimenters ask mainly for 120 GeV protons. The beam spot size at the detectors with proton beam should be about 1 cm x 1cm. The experimenters would also like to perform tests with other particle beams (pions, muons, electrons) at different energies, which will be very useful to understand the background. The beam spot size with these beams should be as close as possible to about 1 cm x 1cm.

2.2.2 BEAM INTENSITY

With 120 GeV protons, intensity should be at least 100K particles per spill.

With other beam particles, the experimenters would like the maximum intensity achievable with the standard beam settings.

2.2.4 BEAM SHARING

Given the goals of the December 2008 test beam, the experimenters foresee that time will be needed to analyze the data and make changes to the setup. Thus, beam time could alternate with other users. The apparatus introduces a minimal amount of material along the beam line, essentially the beam counter scintillators, so parasitic running is possible.

2.2.5 RUNNING TIME

The experimenters would like seven days of beam time for the December 2008 run, with shifts of 14 hours/day. The first two days will be dedicated to set-up the apparatus, the DAQ and the beam timing. In the following days, runs with different settings of beam intensity will be performed. Once optimal conditions are established, fluorescence and Cherenkov measurements will require several hours of data taking in stable beam conditions.

2.3 SETUP

The apparatus for the December 2008 run consists of a dark box, of 60x60x30 cm^3 dimension, containing the integrating sphere (dimensions 18x18x18 cm^3) and the photon detector with its shutter. Two counters at the entrance and exit of the integrating sphere will be used for triggering.

2.3.1 COMPUTING

The experimenters will use their own DAQ system, consisting of a VME crate and controller, and several VME cards (ADC, Peak sensing ADC, TDC, Scaler). The VME crate will be placed in the test beam area close to the apparatus.

III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

([] denotes replacement cost of existing hardware.)

3.1 University of Chicago will provide the following equipment

Photomultipliers	[$2K]
Hybrid Photon Detectors	[$7K]
Mechanics and photon detector shutter control	[$1K]
DAQ system (crate, controller, cards)	[$30K]
1 PC	[$2K]
Digital Oscilloscope	[$5K]
Others (interference filters, optics, mechanics)	[$5K]

Total: $52K

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISIONS:

4.1.1 Use of MTest beam as outlined in Section 2. [.5 person-weeks]

4.1.2 Maintenance of all existing standard beam line elements (hodoscopes, SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.

4.1.3 Beam counter signals, 53 MHz clock, beam-spill gates available in the counting house.

4.1.4 Reasonable access to the experimenters' equipment in the test beam.

4.1.5 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).

4.1.6 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions will be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.

4.1.7 The integrated effect of running this and other SY120 beams will not reduce the antiproton stacking rate or protons on target for NUMI by more than 5%, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION

4.2.1 The test-beam efforts in this MOU will make use of the Meson Test Beam Facility. Requirements for the beam and user facilities are given in Section 2. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and MTest gateway computer and installation tasks such as moving wire chambers. [1.0 person weeks]

4.2.2 A 2-counter beam telescope of 1 cm x 1 cm active area for triggering of beam particles, and a large area counter for beam halo veto will also be provided

4.2.3 The integrating sphere will be provided by the Fermilab group (C. Hojvat), funded by the award of the Strategic Collaborative Initiative Fermilab-University of Chicago

4.3 FERMILAB COMPUTING DIVISION

4.3.1 Ethernet and printer should be available in the counting house.

4.3.2 Connection to beams control console and remote logging (ACNET) should be made available in the counting house.

4.3.3 See Appendix I for summary of PREP equipment pool needs. The experimenters request maintenance for and repair of the PREP-supplied equipment if needed.

4.4 FERMILAB ES&H SECTION

4.4.1 Assistance with safety reviews.

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V. Summary of Costs

Source of Funds [$K]	**Equipment**	**Operating**	**Personnel** (person-weeks)
Particle Physics Division	0	0	1
Accelerator Division	0	0	0.5
Computing Division	0	0	0
Totals Fermilab	$0K	0	1.5
Totals Non-Fermilab	[$52 K]	0	-

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the Leader of the AIRFLY Collaboration and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters": (http://www.fnal.gov/directorate/documents/index.html). The Physicist in charge agrees to those responsibilities and to follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ES&H) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The spokesman of the AIRFLY Collaboration will follow those procedures in a timely manner, as well as any other requirements put forth by the division's safety officer.

6.3 The spokesman of the AIRFLY Collaboration will ensure that at least one person is present at the Meson Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ES&H section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The spokesman of the AIRFLY Collaboration will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Computing Division management. They also undertake to ensure that no modifications of PREP equipment take place without the knowledge and consent of the Computing Division management.

6.7 The AIRFLY Collaboration will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics listed in Appendix II. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.8 At the completion of the experiment:

6.8.1 The spokesman of the AIRFLY Collaboration is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the spokesman of the Iowa group will be required to furnish, in writing, an explanation for any non-return.

6.8.2 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ES&H requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters.

6.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied.

6.9 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters Meeting.

SIGNATURES:

Paolo Privitera

__________________________________ / / 2008
Paolo Privitera, University of Chicago

_______________________________________ / / 2008
Greg Bock, Particle Physics Division

_______________________________________ / / 2008
Roger Dixon, Accelerator Division

_______________________________________ / / 2008
Victoria White, Computing Division

_______________________________________ / / 2008
William Griffing, ES&H Section

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Stephen Holmes, Associate Director, Fermilab

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Young Kee Kim, Deputy Director, Fermilab

APPENDIX I: EQUIPMENT NEEDS

- 1 NIM Model 612AM 6-Channel Photomultiplier Amplifier
- 3 dual gate generator
- 2 logic fan-out
- 2 4-fold coincidence

APPENDIX II - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked

Cryogenics		**Electrical Equipment**		**Hazardous/Toxic Materials**	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		capacitor banks		planned for use in a beam line or experimental enclosure:
	Target	X	high voltage		
	Bubble chamber		exposed equipment over 50 V		
Pressure Vessels		**Flammable Gases or Liquids**			
	inside diameter	Type:			
	operating pressure	Flow rate:			
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:			Lithium (Li)
	window material	Strength:			Mercury (Hg)
	window thickness	**Hazardous Chemicals**			Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other
	Calibration		Methane	**Mechanical Structures**	
	Alignment		TMAE		Lifting devices
type:			TEA		Motion controllers - manual
Wattage:			photographic developers		scaffolding/elevated platforms
class:			Other: Activated Water?		Others

FIGURES:

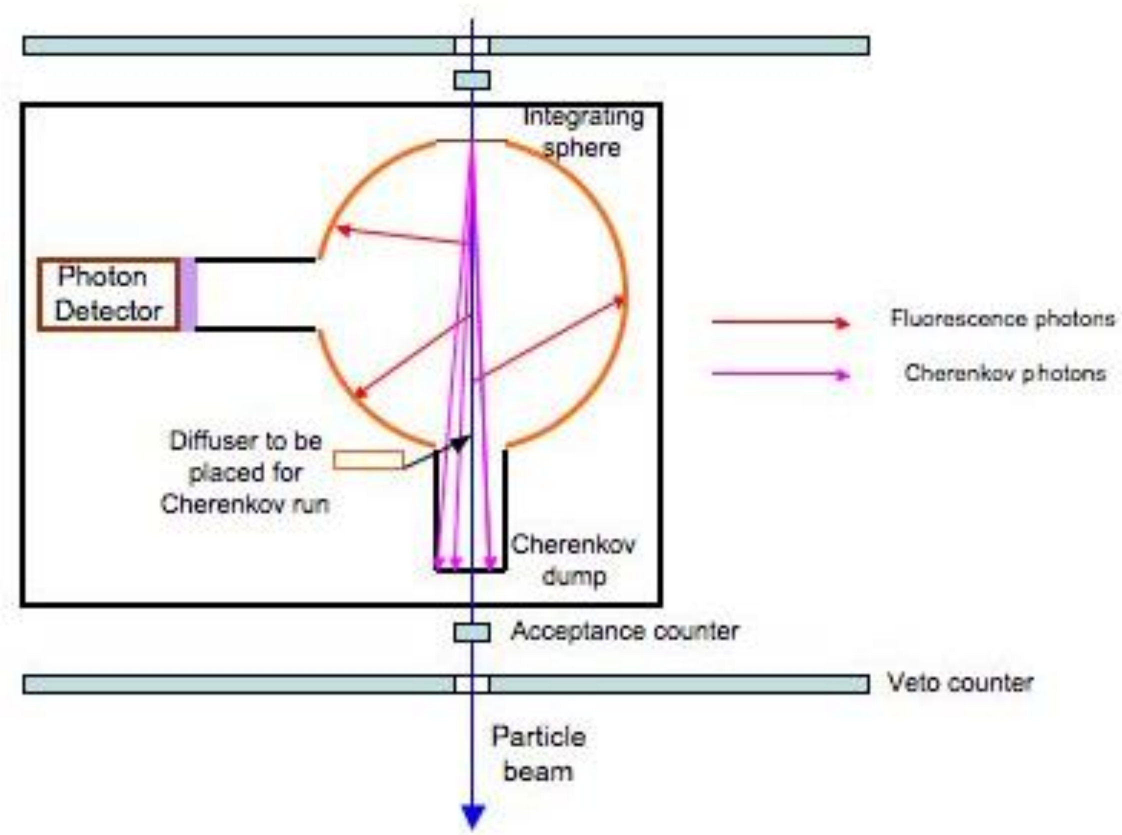

Figure 1: Sketch of the experimental set-up for the absolute fluorescence yield measurement at the Meson Test Beam